THE

ONTARIO WATER RESOURCES

COMMISSION

BIOLOGICAL SURVEY

of the

KAMINISTIKWIA RIVER

and

THUNDER BAY

1965 - 1966

BIOLOGICAL SURVEY

of the

KAMINISTIKWIA RIVER

and

THUNDER BAY

1965-1966

by

M.J.W. German

Biology Branch

April, 1967

TABLE OF CONTENTS

BIOLOGICAL SURVEY OF THE KAMINISTIKWIA RIVER AND THUNDER BAY

1965-1966

INTRODUCTION

The recent expansion at Great Lakes Paper Company Limited, the occurrence of a major fish kill in the Kaministikwia River during the summer of 1966, and the unpalatable nature of fish captured from the river have drawn increasing public attention to the pollution of the Kaministikwia River. Commercial fishermen have been aware of the problem for a number of years. As far back as 1940, fish have acquired unnatural tastes resulting in market rejections and unestimable money losses to these fishermen. Since that time, the commercial fishery of Thunder Bay has slowly declined until at the present time only four commercial fishermen set nets in the bay. Even their efforts are limited to sets during the months of July and August; however, the flesh of these fish will not satisfy the stringent quality requirements of consumers.

Biological surveys of the Kaministikwia River and Thunder Bay were carried out by the Biology Branch in October of 1965 and August of 1966 to reveal the impact of a number of pollution sources on the biota of the Lower Kaministikwia River and adjacent Thunder Bay and to relate these findings to fishing success in these waters.

Bottom fauna diversity and relative abundance will be described and related to the pollution of the Kaministikwia River and Thunder Bay. Bottom fauna have several inherent qualities which are advantageous in pollution investigations. These include limited movement, an extended life cycle and the existence of both pollution-sensitive and pollution-tolerant forms. Because of these attributes, bottom fauna reflect water quality at the sampling point over an extended period of time.

DESCRIPTION OF THE KAMINISTIKWIA RIVER AND THUNDER BAY

The Kaministikwia River originates at a general elevation of 1400 feet, approximately forty miles northwest of the Lakehead. Twin tributaries collect the controlled discharges from Ontario Hydro storage reservoirs at Shebandowan Lake and Dog Lake. Flows from these two branches account for the major portion of the flow in the Kaministikwia River. The upper reaches of the river descend some 750 feet in 32 miles through a series of falls and rapids. Kakabeka Falls, the final downstream falls, supports the only hydro generating station on the river. Possible pollution sources in the upper reaches of the river are limited to small villages such as Kakabeka Falls.

The rapids at Point de Meuron divide the rapidly descending portion of the river from the sluggish lower reaches. Along its final five miles, the river passes through the City of Fort William, dividing twice to form the three channels which eventually discharge to Thunder Bay.

Sources of pollution in the Lower Kaministikwia River at the time of the 1966 biological survey included: untreated sewage from one-half of the 50,000 inhabitants of Fort William; the Great Lakes Paper Company with discharges of both sulphite and Kraft-process wastes; starch wastes from Ogilvie Flour Mills Limited; and sulphite wastes from the Abitibi Power and Paper Company Limited (Mission Mill). Other industries located along the Lower Kaministikwia River include general warehouses and storage depots for grain and fuel.

Major uses of the Kaministikwia River include generation of Hydro-electric power; recreation; aesthetic enjoyment; navigation for seaplane, freight and pleasure craft; assimilation and translocation of wastes; industrial water consumption and a potential water supply for municipal consumption.

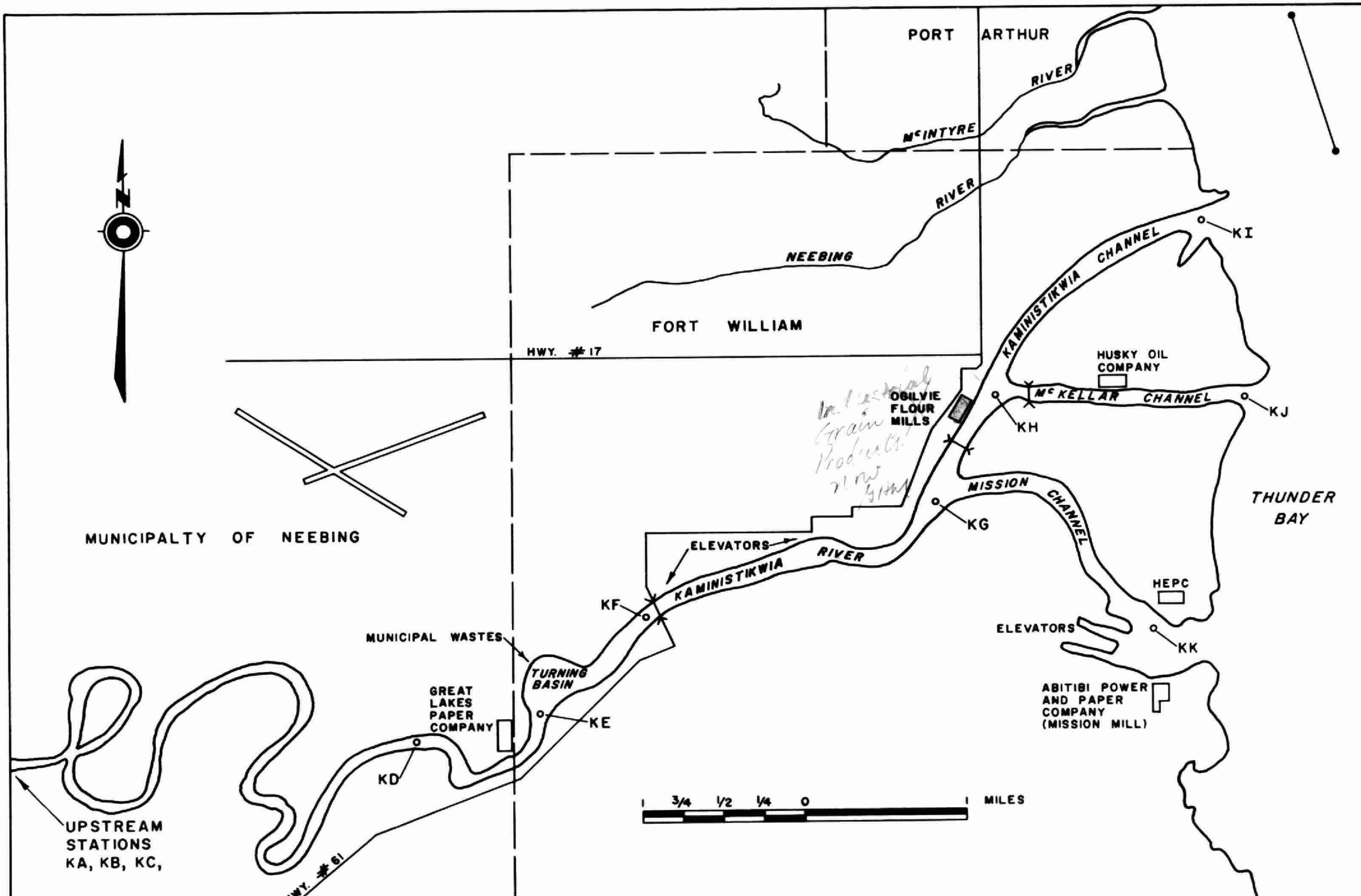
Thunder Bay receives the waters discharged from the Kaministikwia River. Physical boundaries of the Lower Kaministikwia River and Thunder Bay are illustrated in figures 1 and 2, respectively. The bay at its widest point extends fifteen miles in an east-west direction and an approximate distance of sixteen miles from the head of the bay to Pie Island at the mouth of the bay.

For the most part, Thunder Bay has depths in excess of 10 fathoms, and a maximum depth of 50 fathoms approximately one mile west of Clavet Point off the shores of Sibley Peninsula. The Sibley shoreline, unlike the gradual sloping nature of the west shores, is virtually free of shallow waters, with depths of less than 10 fathoms being confined to the extreme shoreline.

Homologous clay sediments, overlain by several inches of gelatinous mud, are typical of the substrate throughout the profundal area of the bay. Various combinations of fibre, bark, cinders, silt, sand, clay and mud were obtained during sampling at the inshore stations.

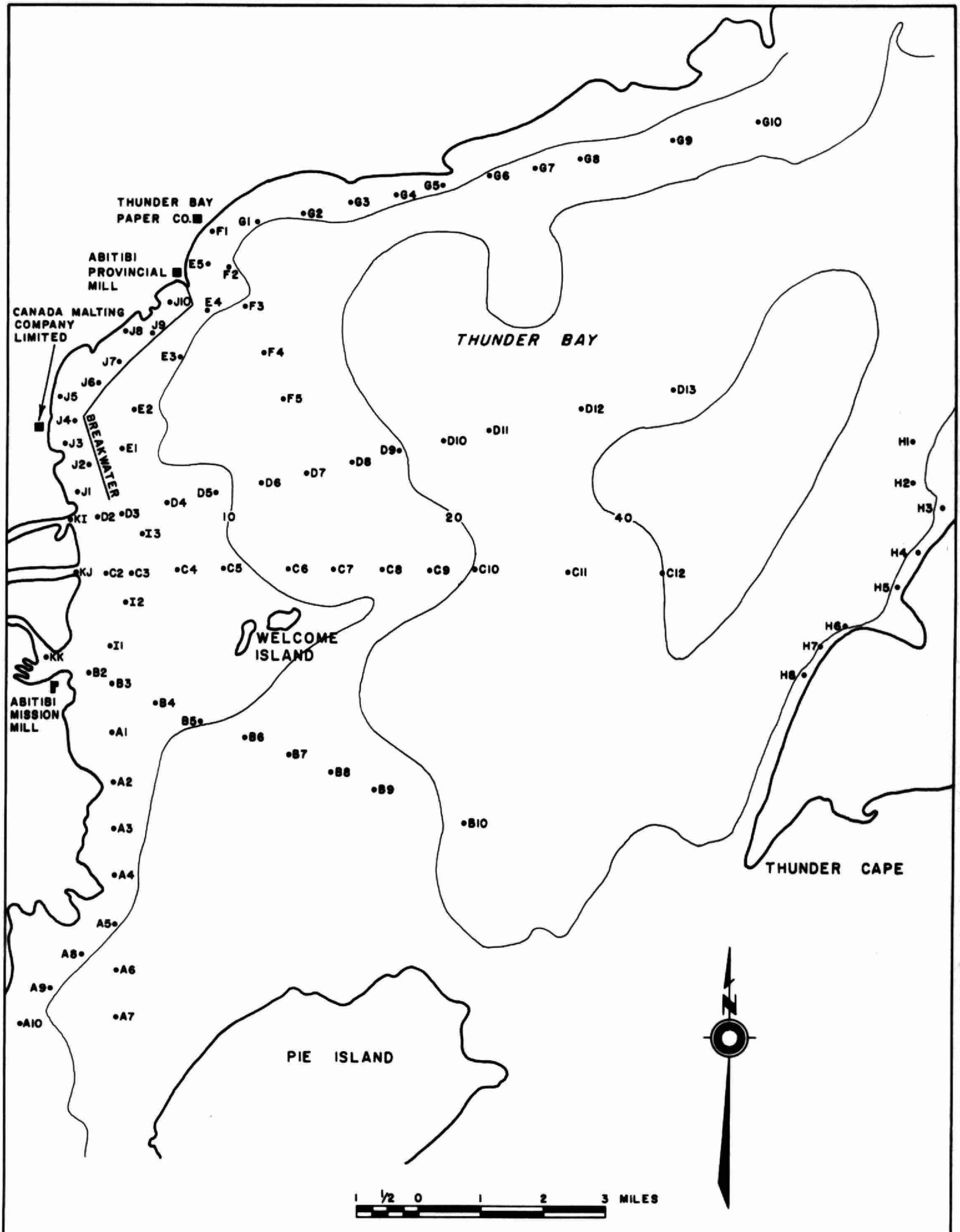
Major sources of pollution entering Thunder Bay include the cumulative wastes carried by the Kaministikwia River, treated municipal wastes from Port Arthur, BOD and suspended solids from Canada Malting Company Limited, and pulp and paper wastes from the Provincial Pulp and Paper Company Limited and the Abitibi Power and Paper Company's Mission Mill and Thunder Bay Division.

Further descriptive information on water pollution and industrial waste discharges may be obtained from the Division of Sanitary Engineering's publications of 1959 and 1960 entitled "Water Resources and Stream Pollution Survey of the Lakehead Area with Recommended Programs" and "Lakehead Area Water Pollution Survey".



KAMINISTIKWIA RIVER

FIG. 1



THUNDER BAY

FIG. 2

METHODS

Data presented in this report were obtained in October of 1965 and during the period from August 3 to August 19, 1966. Locations of survey stations on the Kaministikwia River are shown in Figure 1. Physical, chemical and biological conditions were examined at stations KD to KK in October of 1965. Field work conducted in August of 1966 included a re-examination of conditions at stations KD to KK. Additional samples were obtained from Kakabeka Falls and below highway bridges at routes 588 and 130. These sampling locations have been designated as stations KA, KB and KC. Sediment samples at 83 locations on Thunder Bay were examined for macroinvertebrates during the 1966 survey. Survey stations on Thunder Bay are shown in Figure 2.

Bottom Fauna

The bottom fauna at stations KA, KB and KC were examined with a 20-mesh per inch hand sieve. Fifteen minutes of uniform effort were employed to sample all common habitats at these stations. That is, bottom fauna were collected from eddy waters, exposed reaches, beneath stones, off aquatic vegetation, and any other microhabitats present at the sampling locations.

Macroinvertebrates from all other stations were collected with an Eckman dredge covering an area of 81 square inches. Samples were screened through a 30-mesh per inch box screen. Macroinvertebrates retained by this method were hand-picked into vials containing 95% ethanol and were returned to the laboratory for subsequent identification and enumeration. Bottom fauna values obtained from Eckman dredge samples have been corrected to read individuals per square foot in the text of the report.

Substrate Type

Substrate types were classified in the field by visual inspection. Symbols appearing in Table 4 of the Appendix correspond

to the following substrate types: D = detritus, F = fibre, M = mud, S = sand, Si = silt, C = cinders, Cl = clay, G = gravel, B = bark.

Water Samples

Water sampling in August of 1966 was conducted over a 24-hour sampling period commencing at noon on August 10. Sampling was performed at intervals of approximately four hours. Dissolved oxygen concentrations were determined at each station throughout the 24-hour sampling period, using the azide modification of the Winkler method. Water sampling in October of 1965 was undertaken by the Water Quality Surveys Branch, Division of Sanitary Engineering. Dissolved oxygen concentrations were determined throughout a 24-hour sampling period and water samples for chemical analysis were obtained during four consecutive runs.

Eight water samples for phytoplankton analyses were collected from stations KD to KK during both surveys. For this purpose, forty-ounce samples were fixed with 36 ml. of mercuric chloride and returned to the laboratory for identification and enumeration.

A composite sample of river water immediately below the major effluent discharges from the Great Lakes Paper Company was obtained during the 24-hour sampling period in August of 1966. This sample was shipped by air express to the Toronto laboratory for a toxicity bioassay.

Water samples from Thunder Bay were collected as a composite from three adjacent stations. In addition, samples were collected for phytoplankton analyses at six locations.

In this report, results of the 1966 survey will be interpreted, followed by consideration of the data obtained in 1965.

BIOLOGICAL ASSESSMENT OF WATER QUALITY

Water quality throughout the rapidly ~~descending~~ reaches of the Kaministikwia River was satisfactory for biological production at all stations examined. Bottom fauna communities at stations KA, KB and KC were selected as being representative of this section of the river. Each of these stations supported a variety of organisms but relatively few individuals of any given species. Immature stoneflies, mayflies and caddisflies, present at these stations, are representative of forms known to be sensitive to impaired water quality.

The effluent from the Great Lakes Paper Company is the first major source of pollution entering the Kaministikwia River. Biotic and chemical conditions of the river above and below this effluent are summarized graphically in Figure 3. Specific information on these parameters may be obtained from Tables 1 and 2 in the Appendix of this report.

Bottom fauna were absent from the coarse sand sediments at station KD. These results are reasonable considering the nature of the substrate at this location. Pure sand is often, although not always, incapable of supporting more than a few widely scattered organisms. Chemical parameters indicate that water of excellent quality was present in the river above the Great Lakes mill. River water reaching station KD is extremely soft with an average alkalinity concentration (as $CaCO_3$) of 43 ppm. Dissolved oxygen was present at near saturation levels (80% saturation throughout the 24-hour sampling period), suspended solids were present in low concentrations (4 ppm) and the biochemical oxygen demand averaged 0.5 ppm throughout the 24-hour sampling period.

Only the tubificid species Limnodrilus hoffmeisteri, a sludgeworm capable of withstanding severe organic pollution, was collected at a point 500 feet below the wastes discharges from the

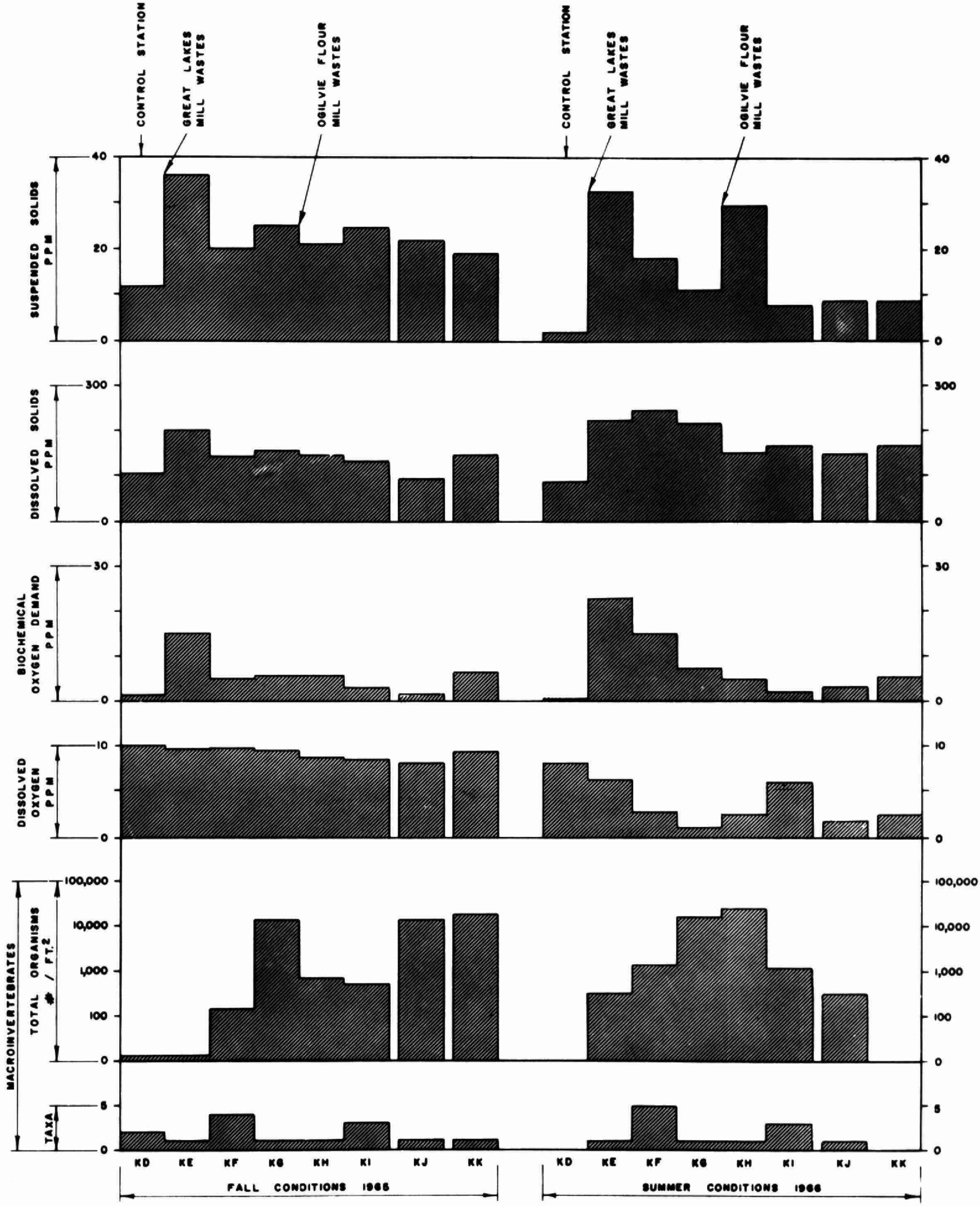


FIG. 3 CHEMICAL AND BIOTIC CONDITIONS AT EIGHT STATIONS ALONG THE LOWER KAMINISTIKWIA RIVER SHOWING EFFECTS OF ORGANIC LOADING AND RECOVERY AS WASTES ARE ASSIMILATED.

Great Lakes Paper Company (station KE), occupying a bottom comprised mainly of accumulations of wood fibre. Wood fibre renders an aquatic environment incapable of supporting a balanced aquatic community through the inter-actions of several factors. Physically, wood fibre clogs the elaborate gill breathing mechanisms of a segment of the benthos, particularly mayflies and caddisflies, thereby eliminating these taxa from the community. Chemically, the decomposition of fibre reduces the dissolved oxygen concentrations and results in the release of toxic gases of decomposition such as hydrogen sulphide. Together, these conditions further reduce the number of organisms, leaving only the most tolerant forms of sludgeworms.

Dissolved oxygen was not a limiting factor at station KE at the time of the survey. Water analyses indicated that a 45 per cent reduction in suspended solids occurred between stations KE and KF. It seems reasonable to postulate that deceleration of water passing through the turning basin would result in a deposition of settleable solids. Probably, the physical effects of settling wood fibre alone would account for the unbalanced nature of the community at station KE.

Dissolved oxygen levels at station KF declined to a dangerous minimum level of 2.0 ppm with a mean 24-hour level of 2.8 ppm. Conditions for bottom fauna were slightly more favourable than at station KE. However, although five taxa of macroinvertebrates were represented, tubificids still predominated, along with limited numbers of midge larvae, isopods and molluscs. Excessive accumulations of wood fibre were not evident in the sediment sample. Undoubtedly, the improvement in bottom fauna was at least partially related to an improvement in the type of substratum.

Bottom fauna and chemical conditions at stations KG and KH indicated serious water quality impairment. Only the pollution

tolerant sludgeworms, Tubifex tubifex and Limnodrilus hoffmeisteri, producing standing crops in excess of 20,000 individuals per square foot, were obtained from the sediments at these stations. The maximum density of sludgeworms occurred at station KH, approximately 100 yards below the waste discharge from Ogilvie Flour Mills. At this location, the standing crop of sludgeworms was in excess of 40,000 individuals per square foot. The exclusive presence of the two sludgeworm species, Tubifex tubifex and Limnodrilus hoffmeisteri, indicates heavy organic pollution, and the order of abundance of these worms is significant in pinpointing the sources of pollution. Sludgeworm populations of the magnitude present at stations KG and KH are attainable only in the presence of an abundant food supply. The population of 20,000 sludgeworms per square foot at station KG was attributable to organic wastes from the Great Lakes Paper Company and untreated domestic wastes from Fort William. The larger standing crop of sludgeworms (40,000 individuals per square foot) at station KH resulted from additional enrichment supplied by wastes from Ogilvie Flour Mills, the only source of enrichment between stations KG and KH.

Dissolved oxygen levels at both stations KG and KH reached a critical minimum level of 0.0 ppm during the observation period. The dissolved oxygen sag for the Kaministikwia River reached its apparent peak low at station KG with a mean 24-hour concentration of 1.0 ppm. Water quality improved slightly below this location following the apportionment of wastes between the main channel and the alternate route through the Mission Channel. The corresponding dissolved oxygen level for the downstream station (KH) was 2.7 ppm.

As described above, the Mission Channel of the Kaministikwia River branches from the main channel downstream from station KG, carrying with it an undetermined portion of the

unassimilated wastes. At the mouth of the Mission Channel, excessive accumulations of wood fibre devoid of even the pollution-tolerant sludgeworms were obtained from the dredge sample at this location (station KK). Dissolved oxygen levels during the sampling period revealed critical minimum and mean concentrations of 1.0 and 2.5 ppm.

The source of wood fibre obtained at station KK is not obvious. The Abitibi Mission Mill is located adjacent to station KK. However, wastes discharged from the Mission Mill are prevented access to the Mission Channel by an extended breakwall. In the past, there have been occasions where seepage has occurred through breaches in the breakwall but this situation had been corrected prior to this survey.

Unassimilated wastes passing station KH below Ogilvie Flour Mills are divided between the Kaministikwia Channel and the McKellar Channel. Both bottom fauna and chemical parameters indicated that a significant portion of the biochemical oxygen demand had been satisfied at the mouths of these two channels. Dissolved oxygen concentrations averaged 6.0 ppm at the mouth of the Kaministikwia Channel (station KI). Bottom fauna secured from this station indicated an improvement in water quality, with a noticeable decrease in the standing crop of sludgeworms and the re-establishment of molluscs in limited numbers.

Similar results were obtained for station KJ at the mouth of the McKellar Channel. Dissolved oxygen levels were approaching a level considered to be satisfactory for aquatic life (4.0 ppm), and the sludgeworm population was greatly reduced in density and altered in composition. While the standing crop of 500 sludgeworms per square foot was predominantly comprised of Tubifex tubifex and Limnodrilus hoffmeisteri, a limited invasion by two additional tubificids, Limnodrilus cervix and Peloscolex multisertosis, indicated an improvement of water quality.

Results of the survey conducted in October of 1965 indicated that pollution was severe throughout the entire river below Great Lakes Mills. In comparing the October and August surveys, water temperature must be considered a significant factor. The average surface temperatures for the Lower Kaministikwia River were 6.6^{O}C in August of 1966. During cold water conditions the solubility of dissolved oxygen increases, providing more oxygen for the assimilation of wastes. However, at these colder temperatures, the assimilation capacity of a stream is severely impeded by a reduction in the metabolic rate of reducer organisms. The net result of these factors should be that dissolved oxygen concentrations remain relatively higher and wastes travel farther downstream during cold water conditions.

Data obtained in October of 1965 (see Figure 3) agreed generally with this theory. Dissolved oxygen concentrations remained relatively constant, varying between a maximum of 10.4 ppm at station KD and a minimum of 8.0 ppm at station KI. Sludgeworm populations reached peak densities at the mouths of the river, indicative that nutrients were more abundant at these localities during the fall conditions than at the corresponding stations during the summer. The notable exception to the hypothesis mentioned was biochemical oxygen demand. The reason for the rapid reduction in BOD is not readily apparent. Probably a large portion of the organic matter settled to the bottom without experiencing immediate assimilation.

Data obtained from the analyses of water samples collected from the Kaministikwia River are presented in Table 3 of the Appendix. These data generally support the observations based on bottom fauna populations. All chemical parameters examined, excluding dissolved oxygen concentrations, attained maximum concentrations at station KE immediately below the waste discharge from

The Great Lakes Paper Company. These concentrations decreased downstream, with a secondary elevation in suspended solids occurring below the effluent from Ogilvie Flour Mills Limited and a general elevation in the concentration of all chemical parameters at the mouth of the Mission Channel. The levels of dissolved oxygen, biochemical oxygen demand and suspended solids are particularly pertinent in the interpretation of the biological data and as such have previously been related to biotic conditions.

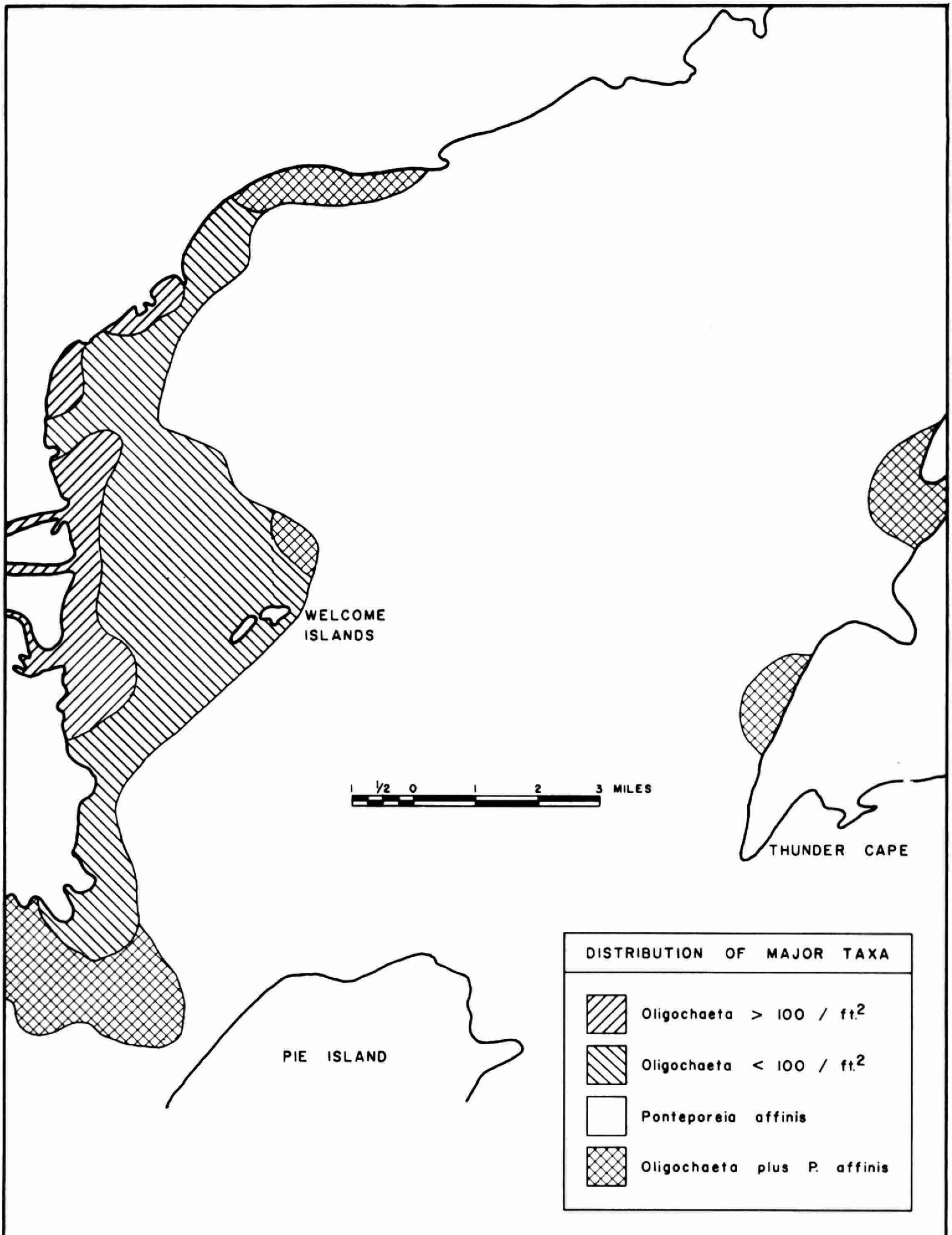
Phytoplankton analyses are presented in Table 3 of the Appendix. Data obtained from these analyses are insufficient to accurately assess the relationship existing between algal populations and the quality of the water in the Lower Kaministikwia River. Remarkably low densities of algae were present in the river. An average low count of 166 areal standard units per ml. was obtained from stations KD to KK in August of 1966. Similarly, low average counts of 29 areal standard units per ml. were obtained from the October 1965 survey. In any event, the role of phytoplankton in the oxygen budget of the Lower Kaministikwia River would appear to be relatively insignificant.

A composite sample collected during the 1966 biological survey was employed to bioassay river water immediately below the Great Lakes Paper Company's wastes discharges. Results of this bioassay indicated that river water at the sampling location was not directly toxic to the moderately sensitive fathead minnow, Pimephales promelas, at a concentration of 56% by volume, over a period of 140 hours. However, reductions in dissolved oxygen concentrations, unquestionably related to this and other discharges, created lethal dissolved oxygen levels in the lower reaches of the river.

Thunder Bay

Eleven taxa of macroinvertebrates were collected from the bottom sediments at 83 locations on Thunder Bay. Figure 4 illustrates the distribution of the two more abundant taxa. Specific biological and chemical data from Thunder Bay are included in Tables 4 and 5 of the Appendix.

Large standing crops of pollution-tolerant sludgeworms were obtained at the mouths of the Kaministikwia River and within the breakwaters of the Lakehead Harbour. Sludgeworm populations ranged outward from these locations in decreasing abundance to a depth of approximately 10 fathoms. At this depth, the amphipod, *Ponteporeia affinis*, an organism common to clean, cold and deep waters, became the dominant taxon. Limited overlapping of sludgeworm and amphipod populations occurred along the shores of Sibley Peninsula and at the extreme ranges of sludgeworm distribution along the western shores. At depths greater than 10 fathoms, sludgeworms were sporadically distributed with no apparent relation to sources of nutrients. However, the areas of maximum sludgeworm abundance in waters with less than 10 fathoms of depth coincided very closely with known sources of enrichment. Three areas within the Lakehead Harbour had sludgeworm densities in excess of 100 individuals per square foot. These included the southernmost extremity of the harbour, influenced by water from the Kaministikwia River and treated sanitary wastes carried by the McIntyre River from the Port Arthur Water Pollution Control Plant, a second area surrounding stations J3, J4 and J5, and a third area at the northernmost extremity of the harbour, the receiving area for the discharge from the Provincial Pulp and Paper Company Limited. Similar densities of sludgeworms extended outwards in Thunder Bay to a distance of approximately one mile from the mouths of the Kaministikwia Channel and the McKellar Channel, while sludgeworm



THUNDER BAY

FIG. 4

densities in excess of 100 individuals per square foot penetrated the bay for a radius of approximately two miles from the mouth of the nutrient-rich Mission Channel.

Other macroinvertebrates collected from the sediments of Thunder Bay included fingernail clams, snails, isopods and midge larvae. These organisms are moderately tolerant to organic pollution. While the occurrence of these organisms in Thunder Bay was sporadic, certainly not as clear-cut as the distributions of sludgeworms and amphipods, some consistency of distribution was evident, with a preponderance of these organisms in the transition zone from sludgeworms to amphipods. The occurrence of these moderately tolerant organisms in the transition zone described above was an indication of improved water quality. On the basis of biological and chemical data obtained during this survey, the area of Thunder Bay (Figure 4) which corresponds to the distribution of Ponteporeia affinis may be interpreted as being the area of relatively unimpaired water quality.

An area of approximately one mile radius in the vicinity of Abitibi Power and Paper Company's Thunder Bay Mill was devoid of even sludgeworms. Large accumulations of wood fibre were evident from sediment samples in this section of the bay. Conceivably, water exchange in this sheltered section of the bay would be minimal, thereby allowing rapid settling of solids and resulting in a substrate unsuitable for even sludgeworm habitation.

Chemical analyses of water samples from Thunder Bay generally support the biological data. Concentrations of solids and BOD (biochemical oxygen demand) were maximum at the mouths of the Kaministikwia River and throughout the Lakehead Harbour. Rapid dilution and self-purification reduced these concentrations to normal bay levels within a few miles of their source.

CONCLUSIONS

Biological and chemical data gathered during biological surveys in October, 1965 and August, 1966 provide evidence to support a number of conclusions concerning the water quality of the Kaministikwia River and Thunder Bay.

The water quality of the Kaministikwia River was unimpaired as far downstream as station KD, located approximately five miles from the river mouths. Water quality below station KD was severely impaired as a result of industrial and domestic wastes. Considerable improvement in water quality was evident at the mouths of the Kaministikwia Channel (station KI) and the McKellar Channel (station KJ) during August of 1966. Water of reasonably good quality was present along the western shore of Thunder Bay, with only localized areas of organically contaminated water near the mouths of the Kaministikwia River, within the Lakehead Harbour, and in the vicinity of waste discharges from the Abitibi Power and Paper Company's Thunder Bay Division. A relatively large portion of Thunder Bay contained water of excellent quality.

Specifically, the results of biological surveys of the Kaministikwia River have demonstrated that:

1) Wood fibre losses from the Great Lakes Paper Company have resulted in excessive wood fibre accumulations at station KE, thereby producing a substrate untenable for normal macroinvertebrate habitation.

2) Organic wastes from the Great Lakes Paper Company and untreated domestic wastes from the City of Fort William were directly responsible for the unbalanced nature of the bottom fauna communities at stations KE, KF and KG and the inadequate dissolved oxygen concentrations at stations KF and KG.

3) Starch wastes discharged from Ogilvie Flour Mills Limited further compounded the organic enrichment of the Kaministikwia River, resulting in the undesirable and unbalanced nature of the bottom fauna at station KG.

4) Excessive accumulations of wood fibre of undetermined origin were responsible for the absence of benthic organisms at the mouth of the Mission Channel and the unbalanced nature of the bottom fauna communities in Thunder Bay at the mouth of the Mission Channel.

5) Cumulative wood fibre losses from the Abitibi Power and Paper Company's Thunder Bay Mill were responsible for the absence of benthic organisms at stations F1 and F2 on Thunder Bay.

6) The water quality within the Lakehead Harbour was moderately to heavily impaired.

RECOMMENDATIONS

1. That connection of trunk sewers to the unserviced section of Fort William progress as scheduled.

2. That the Great Lakes Paper Company continue to implement its staged programme for waste control with the minimum of delay.

3. That Ogilvie Flour Mills design and implement a waste treatment programme designed specifically to remove BOD and solids to meet the Commission's requirements.

4. That further investigative work be undertaken by the Commission to determine the source of wood fibre present in the sediments at the mouth of the Mission Channel.

5. That the Abitibi Power and Paper Company Limited, Thunder Bay Division, provide further removal of wood fibre from waste discharges.

6. That further investigations be conducted by the Biology Branch to ascertain the sources of pollution in the Lakehead Harbour, with particular attention being directed towards the effects of waste discharges from Canada Malting Company Limited, the Provincial Pulp and Paper Company Limited, and primary treatment wastes from the City of Port Arthur. Also, the source of wood fibre present in the vicinity of the Mission Mill should be ascertained.

Properly designed and executed waste treatment programmes at the above-mentioned sources of organic enrichment will allow maximum utilization of the surface waters of the Kaministikwia River and Thunder Bay for wastes assimilation and translocation while maintaining an environment suitable for aquatic life.

ACKNOWLEDGEMENTS

The Ontario Department of Lands and Forests provided technical assistance and a boat for river sampling. Laboratory facilities were provided by Mr. A. Robson and Mr. R. Romonick, chief plant operators for the Fort William and Port Arthur Water Pollution Control Plants.

REFERENCES

Ontario Water Resources Commission. 1959. Water resources and stream pollution survey of the Lakehead area with recommended programs. Div. of San. Eng., OWRC. 59p.

Ontario Water Resources Commission. 1960. Lakehead area water Pollution survey. Div. of San. Eng., OWRC. 43p.

Report approved by:

C.F. Schenk

C.F. Schenk, Supervisor,
Biology Branch

Report prepared by:

M.J. German

M.J.W. German, Biologist

APPENDIX

SUMMARY OF ANALYTICAL DATA

Table 1. Macroinvertebrates collected at 11 stations on the Kaministikwia River in October of 1965 and August, 1966. Collecting methods are outlined in the text of the report.

		STATIONS										
		Qualitative*			Qualitative and Quantitative							
Taxa	Date	KA	KB	KC	KD	KE	KF	KG	KH	KI	KJ	KK
STONEFLIES												
Acroneuria	1965											
	1966	2		1								
MAYFLIES												
Ephemera	1965											
	1966		5									
Heptagenia	1965											
	1966			2								
CADDISFLIES												
Hydropsyche	1965											
	1966			1								
Cheumatopsyche	1965						2					
	1966	1		4								
Chimarra	1965						2					
	1966											
DAMSELFIES												
Agrion	1965											
	1966			2								
FISHFLIES												
Sialis	1965											
	1966		1									
BEETLES												
Unidentified	1965											
	1966		1									
BUGS												
Corixidae	1965											
	1966		1									
Rhagavelia	1965											
	1966			3								
ISOPODS												
Asellus	1965									4		
	1966	10	2				2					
CRAYFISH												
Orconectes	1965											
	1966		1	1								
MOLLUSCS												
Pisidium	1965											
	1966									9		
Sphaerium	1965											
	1966		7				7					
Physa	1965											
	1966	3		3			2					
Unidentified	1965											
	1966									4		

Table 1. - continued

Taxa	Date	STATIONS Qualitative* KA	KB	KC	Qualitative and Quantitative KD	KE	KF	KG	KH	KI	KJ	KK
LEECHES												
Dina	1965									2		
	1966	2										
MIDGES												
Chironomidae	1965				2	7	2					
	1966	1					7					
FLIES												
Palpomyia	1965				5							
	1966											
WORMS												
Oligochaeta	1965						160	11,500	775	675	11,500	21,500
	1966					550	1900	20,000	40,000	1300	500	

*Qualitative - stations KA, KB and KC were sampled only in 1966 (see section on methods).

Table 2. Chemical analyses of water samples collected on October 5, 1965 and August 10, 1966, from eleven stations (KA-KK) on the lower Kaministikwia River.

Sta.	Date	Temp. °C Max.	Temp. °C Min.	Dissolved Oxygen Max.	Dissolved Oxygen Min.	Dissolved Oxygen Mean	BOD 5 day	SOLIDS susp.	SOLIDS diss.	Nitrogen TKN	Phenol (ppb)	Hardness $CaCO_3$	Sodium Na	Calcium Ca	Sulphite SO_3	pH (Lab)
KA	1966	20	20	8.5	8.5	8.5		4	90	0.26	4.0	42	1.0	11.0	0.3	7.8
KB	1966	21	21	8.0	8.0	8.0		3	97	0.40	2.0	42	1.0	11.0	0.0	7.8
KC	1966	19	19	7.5	7.5	7.5		4	102	0.40	2.0	46	1.0	12.0	0.0	7.6
KD	1965	7.0	5.5	11.2	9.6	10.4	1.3	12	103	0.63	2.5	42	1.2	10.0	1.3	6.7
	1966	17.0	15.0	8.5	8.0	8.1	0.5	2	94	0.26	4.0	44	3.0	11.0	2.0	8.1
KE	1965	9.0	5.0	10.4	9.2	9.7	15.1	36	199	0.75	8.0	51	1.0	10.5	2.5	6.5
	1966	19.0	16.0	7.5	4.5	6.3	23.0	33	225	0.71	30.0	70	22.0	18.0	4.0	7.7
KF	1965	7.0	5.0	10.8	9.2	9.8	4.7	20	140	0.75	4.0	47	1.2	9.0	2.5	6.5
	1966	18.0	15.5	3.0	2.0	2.8	15.0	18	246	0.65	10.0	74	23.0	19.0	4.0	7.6
KG	1965	7.0	6.0	10.0	8.4	9.4	5.6	25	157	0.76	7.5	51	1.4	9.0	2.8	6.6
	1966	17.0	15.5	1.0	0.0	1.0	7.6	11	217	0.58	20.0	70	22.0	17.0	3.0	7.6
KH	1965	7.0	6.0	9.2	6.5	8.7	5.6	21	142	0.78	7.0	51	1.5	11.0	1.9	6.6
	1966	15.5	14.0	5.0	0.0	2.7	4.8	30	150	0.58	10.0	66	16.0	18.0	2.0	7.6
KI	1965	8.0	6.0	8.0	5.8	8.5	2.6	25	130	0.83	4.0	57	2.8	14.0	1.4	6.6
	1966	15.0	12.5	8.5	3.5	6.0	2.0	8	164	0.52	6.0	62	12.0	17.0	3.0	7.4
KJ	1965	7.0	8.0	8.4	7.6	8.0	1.2	22	96	0.57	3.0	59	1.7	16.0	2.1	6.7
	1966	15.5	13.0	7.5	1.5	3.9	3.0	9	151	0.46	8.0	62	13.0	18.0	2.0	7.4
KK	1965	6.0	7.0	10.0	8.8	9.3	6.0	19	145	0.76	5.0	53	1.4	11.5	1.9	6.7
	1966	15.5	15.0	5.0	1.0	2.5	5.6	9	165	0.52	10.0	66	16.0	17.0	2.0	7.5

Table 3. Phytoplankton analyses of samples collected on October 5, 1965 and August 10, 1966, from 8 stations (KD to KK) on the Lower Kaministikwia River

	STATIONS															
	KD		KE		KF		KG		KH		KI		KJ		KK	
TAXA	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966
BLUE GREENS																
Anabaena			5						2						1	
Aphanizomenon	1															
Gomphosphaeria				23	9											
Oscillatoria	4				6	31					2				2	
FLAGELLATES																
Chlamydomonas			1	172	1	36		158	2	13	1	40		131	1	17
Dinobryon	3													15	4	
Eudorina												31				
Euglena							2				1		<0.5			
Peridinium			1											26		
Synura	<0.5										1					
Trachelomonas	<0.5						1									
GREENS																
Ankistrodesmus			2		<0.5								<0.5		1	
Closterium		12							8						9	12
Cosmarium											3					
Oocystis	1											5				
Schroederia																
DIATOMS																
Asterionella	6		5		2				1		2		2		2	
Cyclotella	1	38	3	4					2	7		9	2	13		
Cymbella					1										1	
Flagilaria					3		2						1			
Melosira					5								<0.5			
Navicula	8	12	5		2		2		2			16	1		3	
Synedra		49	7	124	22	34	2	10	13	4	3		1	4	11	17
Tabellaria	12	10					3		1				12		4	
Gomphonema				65	1	24										
Diatoma													2			
Eunotia												69				
Meridion															3	
Cocconeis															1	
Total Taxa	10	5	8	5	11	4	6	2	8	3	7	6	10	5	13	3
Total A.S.U. per ml.	36	121	29	388	47	125	12	168	19	27	13	170	21	189	43	143

Table 4. Depth of water, distance from enrichment source, bottom type and density (no./ft^2) of bottom fauna at 83 stations on Thunder Bay, 1966. Station locations are shown in Figure 2.

Station	Depth (fathoms)	Miles from enrichment	Bottom Type	Oligochaeta	Pontoporeia affinis	Gammarus	Asellus	Chironomidae	Pisidium	Sphaerium	Gyraulus	Valvata	Mysis	Total Taxa	Total Organisms
A1	3	2	DMCl	47				4	7					3	58
A2	3	3	DMCl	36				2	7					3	45
A3	6	4	DMCl	4				9	11			2		4	26
A4	15	5	MCl	72				41						2	113
A5	19	6	DMCl	43	70			5						3	118
A6	20	7	MCl	4	38			5	2					4	49
A7	21	8	MCl	5	36			2	4					4	47
A8	13	6	MCl	7	20			2						3	29
A9	9	7	MCl	5	4			2						3	11
A10	7	8	MCl	4	18			2	2					4	26
B2	5	½	FSi	700			2							2	702
B3	5	1	FSi	290			16	5	11	2				4	322
B4	6	2	DCl	173										1	173
B5	10	3	SCl	20				5						3	27
B6	16	4	MCl		59			2						2	61
B7	15	5	MCl	2	21									2	24
B8	15	6	MCl		59								1	2	60
B9	17	7	MCl		20		2							2	22
B10	21	9	MCl		106			2	16					3	124
C2	4	½	FM	1600				70	23	4				4	1697
C3	3	1	FM	50					2					2	52
C4	4	2	MCl	31				2		2				3	35
C5	8	3	FSCl	25				7						2	32
C6	12	4	SMCl	40	4									2	44
C7	16	5	CCl		5									1	5
C8	18	6	MCl		41			5						2	46
C9	24	7	MCl		14			2						2	16
C10	30	8	MCl	4	16									2	20
C11	40	10	MCl		63			2	5	2			1	4	74
C12	45	12	MCl		49			2						2	51
D2	5	½	DSi	830				25	23	9				4	887
D3	6	1	DCl	38						2				2	40
D4	6	2	CM	61				5						2	66
D5	10	3	CCl	11				2	5					3	18
D6	13	4	MCl											0	0
D7	14	5	MCl	5	34			2						3	41
D8	17	6	MCl		7									1	7
D9	20	7	MCl		5			5						2	10
D10	24	8	MCl		14									1	14
D11	26	9	MCl		14									1	14
D12	32	11	MCl	2	2									2	4
D13	42	13	MCl		2									1	2

Continued

Table 4. Depth of water, distance from enrichment source, bottom type and density (no./ft^2) of bottom fauna at 83 stations on Thunder Bay, 1966. Station locations are shown in Figure 2.

Station	Depth (fathoms)	Miles from enrichment	Bottom Type	Oligochaeta	*Pontaporeia affinis*	*Gammarus*	*Asellus*	Chironomidae	*Pisidium*	*Sphaerium*	*Gyraulus*	*Valvata*	*Mysis*	Total Taxa	Total Organisms
E1	6	1	DM	240			5	14	9	5				5	273
E2	8	1	DS	31										1	31
E3	11	1	DM											0	0
E4	6	1	F											0	0
E5	5	1	DS	23				4	5	2		2		5	36
F1	3	½	F											0	0
F2	10	1	F											0	0
F3	12	2	FM	54				23						2	77
F4	14	3	FM	4				2						2	6
F5	16	4	DSM		2									1	2
G1	10	1	SM	16	58			4	11					4	89
G2	7	2	MCl	47	16									2	63
G3	6	3	SCl	41	27			5	7					4	80
G4	10	4	SMCl	5	92			5	4					4	106
G5	15	5	SM		110			4	4					3	118
G6	11	6	SMCl		36									1	36
G7	13	7	SCl	2	157			4	4					4	167
G8	20	8	SCl	2	36									2	38
G9	20	9	MCl		58			4						2	62
G10	24	10	MCl		58			2	5					3	65
H1	36	15	Gl											0	0
H2	7	15	SCl	2	5				2		4			4	11
H3	6	15	SCl	5	11			7						3	23
H4	12	15	Cl		5									1	5
H5	14	15	SCl		20									1	20
H6	20	15	SCl		38									1	38
H7	18	15	GCl	4	23			4	5					4	36
H8	15	15	S	2	2				2					3	6
I1	6	2	DM	94				5						2	99
I2	4	1	DM	36				4	14	9		4		5	67
I3	4	1	SM	41			2	7	16	4		4		6	74
J1	5		DCl	300				4	14	4				4	322
J2	5		Cl	144					4	4				3	152
J3	6		Cl	29					2					2	31
J4	4		DMCl	121		2	2	9	97	115				6	346
J5	6		DCl	158				47	16	4				4	225
J6	4		DCl	86		5	40	14	41	31				6	217
J7	5		BCl	9			5							2	14
J9	4		BDCl	1980										1	1980
J9	6		BDF	864										1	864
J10	4		BDCl	1600										3	1604

Table 5. Chemical characteristics of water in Thunder Bay during the period August 9 to 15, 1966.

Station	BOD	SOLIDS Susp.	SOLIDS Diss.	Nitro. TKN	Sod. Na	Cal. Ca.	Mag. Mg.	Sulphite SO_3	Hardness $CaCO_3$	pH at Lab
A1	2.5	3	101	0.33	9	16	2	7.0	-	7.5
A3	1.2	1	80	0.07	2	14	4	5.0	-	7.6
A6	0.9	1	73	0.20	2	14	4	0.0	-	7.9
A9	1.0	1	76	0.07	2	14	3	1.0	-	7.9
B2	6.6	10	134	0.40	5	16	6	3.0	-	7.2
B4	2.1	3	95	0.33	4	14	5	5.0	-	7.3
B6	0.8	1	65	0.26	2	14	3	5.0	-	7.9
B9	0.9	1	72	0.13	2	14	3	5.0	-	8.1
C2	2.4	7	115	0.33	8	15	4	1.0	56	8.0
C4	0.6	1	75	0.26	3	14	4	0.0	50	7.9
C6	0.6	2	78	0.20	5	14	3	0.0	48	8.0
C9	0.4	1	79	0.13	4	14	3	0.0	48	8.1
D3	0.9	4	100	0.26	5	14	4	2.0	50	8.0
D6	0.4	1	71	0.20	4	14	3	0.0	48	8.0
D9	0.6	1	83	0.33	4	14	3	0.0	46	8.0
E2	1.9	2	96	0.20	3	14	4	3.0	-	7.8
E5	0.9	2	74	0.07	3	14	3	3.0	-	8.3
F1	1.4	1	123	0.13	3	14	4	5.0	-	7.7
F3	0.9	1	75	0.07	2	14	3	5.0	-	7.9
G2	1.4	2	94	0.07	2	14	3	4.0	-	7.7
G5	0.5	1	71	0.13	2	14	3	0.0	-	7.8
G8	1.0	1	97	0.13	2	14	4	1.0	-	8.0
G10	1.0	1	67	0.07	2	14	3	0.0	-	8.0
H2	0.2	1	71	0.26	4	14	4	0.0	50	8.1
H7	0.8	1	69	0.13	4	14	3	1.0	48	8.1
I2	1.2	2	94	0.20	2	14	3	5.0	-	7.7
J1	1.7	5	93	0.33	6	14	4	0.0	50	8.0
J3	0.8	8	84	0.33	4	14	4	0.0	50	8.1
J6	1.1	4	88	0.40	5	14	4	0.0	50	8.1
J9	1.8	4	96	0.46	4	14	4	0.0	50	8.1

FEB 14 1968			
AUG 12 1969			
JAN - 5 1970			
DEC 17 1971			
SEP 15 1972			
JAN 8 1985			
NOV 18 1987			